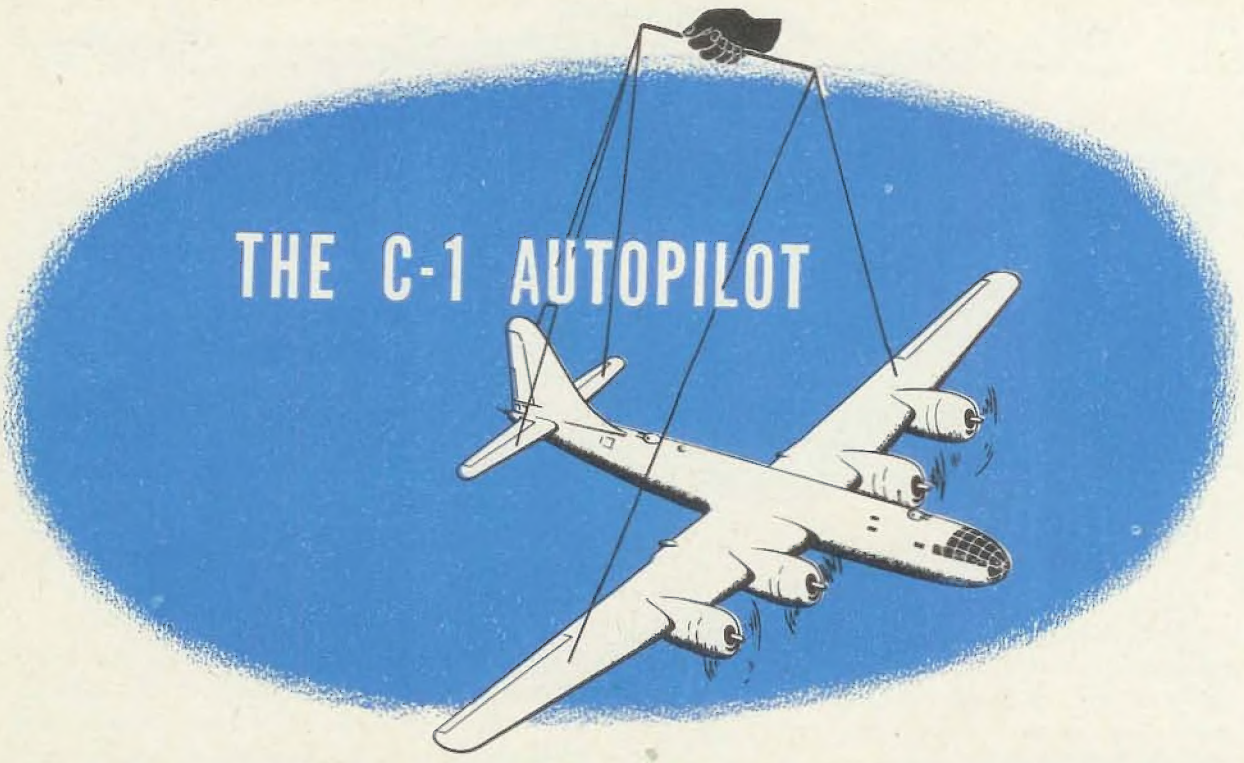


The C-1 autopilot is an electromechanical robot which automatically flies the airplane in straight and level flight, or maneuvers the airplane in response to the fingertip control of the human pilot or bombardier.

Actually, the autopilot works in much the same way as the human pilot in maintaining straight and level flight, in making corrections necessary to hold a given course and altitude, and in applying the necessary pressure on the controls to make turns, banks, etc. The difference is that the autopilot acts instantaneously and with a precision that is not humanly possible.

The precision of even the most skillful human pilot is limited by his own reaction time, i.e., the interval between his perception of a certain condition and his action to correct or control it. Reaction time itself is governed by such human fallibilities as fatigue, inability to detect errors the instant they occur, errors in judgment, and muscle coordination.

The autopilot, on the other hand, detects flight deviations the instant they occur, and just as instantaneously operates the controls to correct the deviations. Properly adjusted, the autopilot neither overcontrols nor undercontrols the airplane, but keeps it flying straight and level with all three control surfaces operating in full coordination.

The C-1 autopilot consists of various separate units electrically interconnected to operate as a system. The operation of these units is explained in detail in AN-11-60AA-1. You can get a general over-all understanding of their functions and relation to each other by studying the accompanying illustration.

Assume that the airplane in the illustration is flying straight and level and that the autopilot is operating.

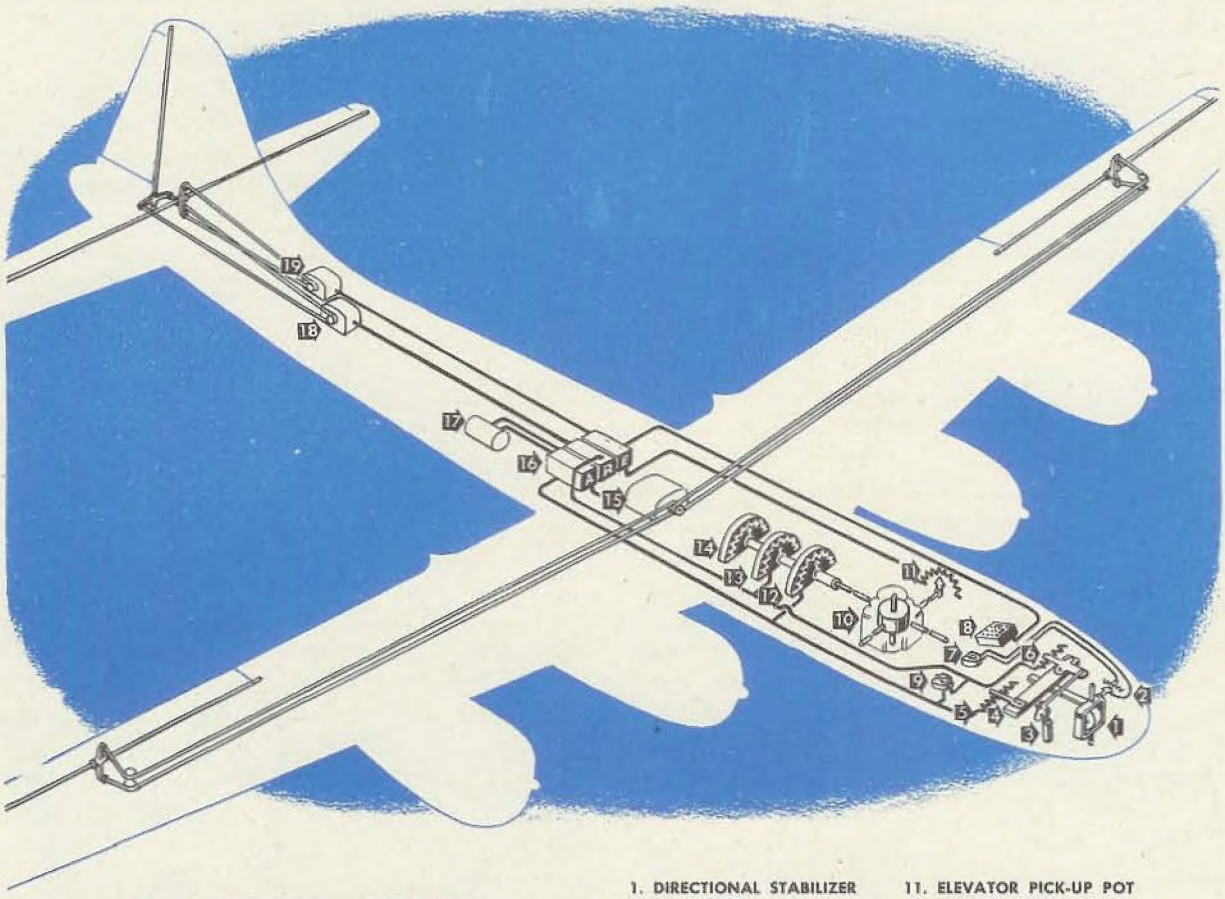
Suddenly a crosswind turns the airplane away from its established heading. The gyro-operated directional stabilizer (1) detects this deviation and moves the directional panel (4)

to one side or the other, depending upon the direction of the deviation.

The directional panel contains two electrical devices, the banking pot (5) and the rudder pick-up pot (6), which send signals to the aileron and rudder section of the amplifier (16) whenever the directional panel is operated. These signals are amplified and converted (by means of magnetic switches or relays) into electrical impulses which cause the aileron and rudder Servo units (15 and 18) to operate the ailerons and rudder of the airplane in the proper direction and amount to turn the airplane back to its original heading.

Similarly, if the nose of the airplane drops, the vertical flight gyro (10) detects the vertical deviation and operates the elevator pick-up pot (11) which sends an electrical signal to the elevator section of the amplifier. The signal is amplified and relayed in the form of electrical impulses to the elevator Servo unit (19) which in turn raises the elevators the proper amount to bring the airplane to level flight.

If one wing drops appreciably, the vertical flight gyro operates the aileron pick-up pot (12), the skid pot (13), and the up-elevator pot (14). The signals caused by the operation of these units are transmitted to their respective



C-I AUTO PILOT

(SCHEMATIC DRAWING . . . DOES NOT SHOW CORRECT LOCATION OR PROPORTION OF UNITS)

1. DIRECTIONAL STABILIZER
2. P. D. I. POT
3. DASH POT
4. DIRECTIONAL PANEL
5. BANKING POT
6. RUDDER PICK-UP POT
7. P. D. I.
8. AUTOPILOT CONTROL PANEL
9. TURN CONTROL
10. VERTICAL FLIGHT GYRO
11. ELEVATOR PICK-UP POT
12. AILERON PICK-UP POT
13. SKID POT
14. UP-ELEVATOR POT
15. AILERON SERVO
16. AMPLIFIER
17. ROTARY INVERTER
18. RUDDER SERVO
19. ELEVATOR SERVO

(aileron, rudder, and elevator) sections of the amplifier. The resulting impulses to the aileron, rudder, and elevator Servo units cause each of these units to operate its respective control surface just enough to bank and turn the airplane back to an even keel or level-flight attitude.

When the human pilot wishes to make a turn, he merely sets the turn control knob (9) at the degree of bank and in the direction of turn desired. This control sends signals, through the aileron and rudder sections of the amplifier, to the aileron and rudder Servo units which operate ailerons and rudder in the proper manner to execute a perfectly coordinated (non-slipping, non-skidding) turn. As the airplane banks, the vertical flight gyro operates the aileron, skid, and up-elevator pots (12, 13, 14). The resulting signals from the aileron and skid pots cancel the signals to the aileron and rudder Servo units to streamline these controls during the turn.

The signals from the up-elevator pot cause the elevators to rise just enough to maintain altitude. When the desired turn is completed, the pilot turns the turn control back to zero and the airplane levels off on its new course. A switch in the turn control energizes the directional arm lock on the stabilizer, which prevents the stabilizer from interfering with the turn by performing its normal direction-correcting function.

The autopilot control panel (8) provides the pilot with fingertip controls by which he can conveniently engage or disengage the system, adjust the alertness or speed of its responses to flight deviations, or trim the system for varying load and flight conditions.

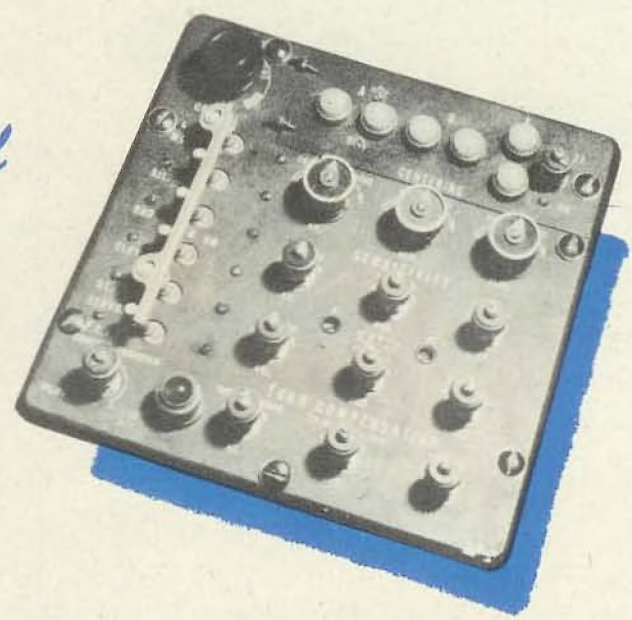
The pilot direction indicator, or PDI (7), is a remote indicating device operated by the PDI pot (2). When the autopilot is used, the PDI indicates to the pilot when the system and airplane are properly trimmed. Once the autopilot is engaged, with PDI centered, the autopilot makes the corrections automatically.

The rotary inverter (17) is a motor-generator unit which converts direct current from the airplane's battery into 105-cycle alternating current for operation of the autopilot.

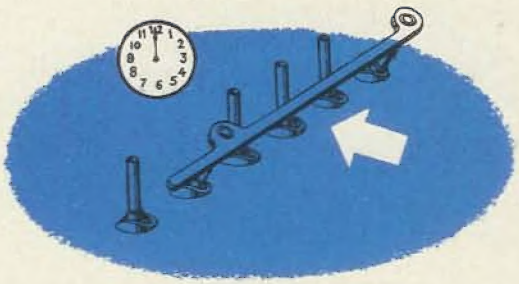
Before Takeoff

1. Turn control centered.

2. Make sure that all switches on the control panel are in the OFF position.

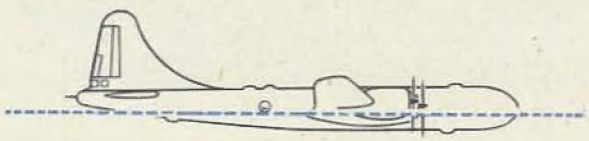


After Takeoff



1. Turn on the master switch.

2. Ten minutes later, turn on PDI switch (and Servo switch, if separate.)

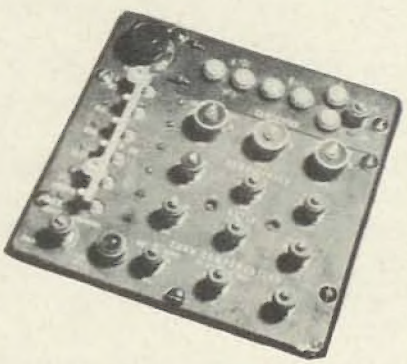


3. Ten minutes after turning on the master switch, trim the airplane for level flight at cruising speed.

4. Have the bombardier disengage the autopilot clutch, center PDI and lock it in place by depressing the directional control lock. The PDI is held centered until the airplane commander has completed the engaging procedure. Then the autopilot clutch is re-engaged, and the directional arm lock released.

Alternate Method: The airplane commander centers PDI by turning the airplane in direction of the PDI needle. Then resume straight and level flight.

5. Engage the autopilot. Put out aileron telltale lights with the aileron centering knob, then throw on the aileron engaging switch. Repeat the operation for rudder, then for elevator.

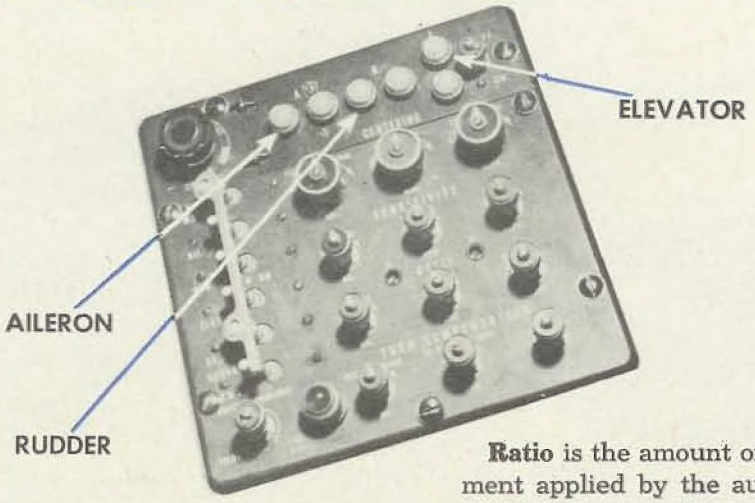


6. Make final autopilot trim corrections. If necessary, use centering knobs to level wings and center PDI.

CAUTION

Never adjust mechanical trim tabs while the autopilot is engaged.

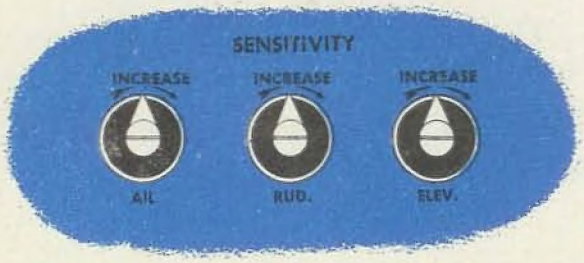
FLIGHT ADJUSTMENTS AND OPERATION



After the C-1 autopilot is in operation, the pilot should carefully analyze the action of the airplane to make sure all adjustments have been made properly for smooth, accurate flight control.

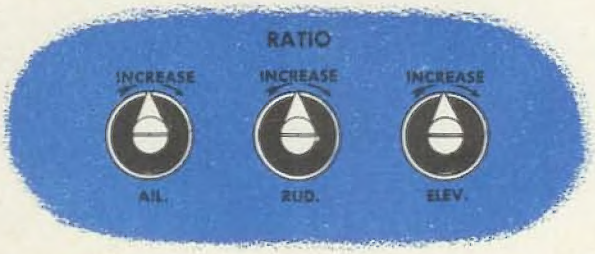
When both **tell-tale lights** in any axis are extinguished, it indicates the autopilot is ready for engaging in that axis.

Before engaging, use each **centering knob** to adjust the autopilot control reference point to the straight and level flight position of the corresponding control surface. After engaging, use the centering knobs to make small attitude adjustments.



Sensitivity is comparable to a human pilot's reaction time. With sensitivity set high, the autopilot responds quickly to apply a correction for even the slightest deviation. If sensitivity is set low, flight deviations must be relatively large before the autopilot applies its corrective action.

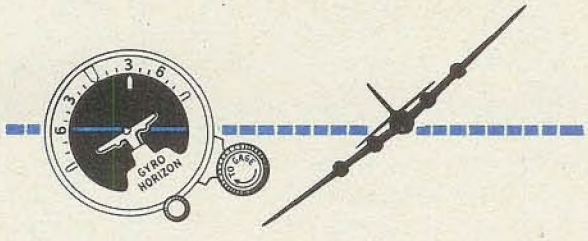
Ratio is the amount of control surface movement applied by the autopilot in correcting a given deviation. It governs the speed of the airplane's response to corrective autopilot actions. Proper ratio adjustment depends on airspeed. If ratio is too high, the autopilot overcontrols the airplane and produces a ship-hunt; if ratio is too low, the autopilot undercontrols, and flight corrections are too small. After ratio adjustments have been made, centering may require readjustment.



To adjust **turn compensation**, have bombardier disengage autopilot clutch and move engaging knob to extreme right or extreme left. Airplane should bank 18° as indicated by artificial horizon. If it does not, adjust aileron compensation (bank trimmer) to attain 18° bank. Then, if turn is not coordinated, adjust rudder compensation (skid trimmer) to center inclinometer ball. Do not use aileron or rudder compensation knobs to adjust coordination of turn-control turns. Recovery from a bombardiers turn must be coordinated. If the PDI returns to center before the wings are level,

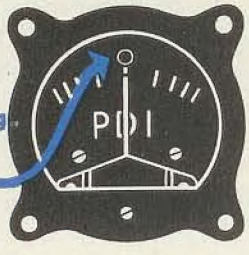
decrease the rudder ratio or increase the aileron ratio, depending on the speed of the recovery. If the wings are level before the PDI is centered, increase rudder ratio or decrease aileron ratio, depending on the speed of recovery.

The airplane commander uses the **turn control** to turn the airplane while flying under automatic control. To adjust turn control, first make sure turn compensation adjustments have been made properly, then set turn control pointer at beginning of trip-lined area on dial.



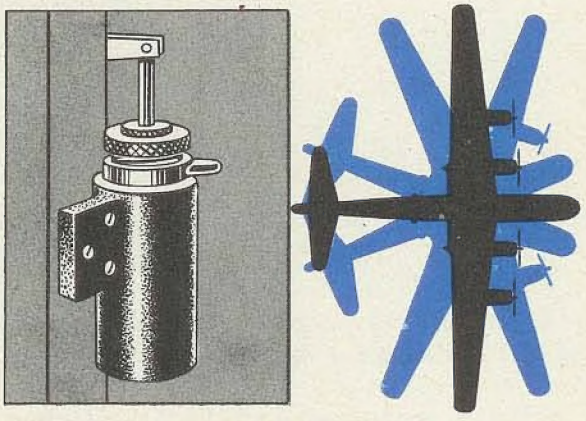
Airplane should bank 30°, as indicated by artificial horizon. If not, remove cap from aileron trimmer and adjust trimmer until a 30° bank is attained. Then, if turn is not coordinated, (inclinometer ball not centered), adjust rudder trimmer to center ball. Make final adjustments with both trimmers and replace caps. Set turn control at zero to resume straight and level flight; then re-center.

Never operate the Turn Control without first making sure the PDI is centered



The **turn control transfer** has no effect unless the installation includes a remote turn control.

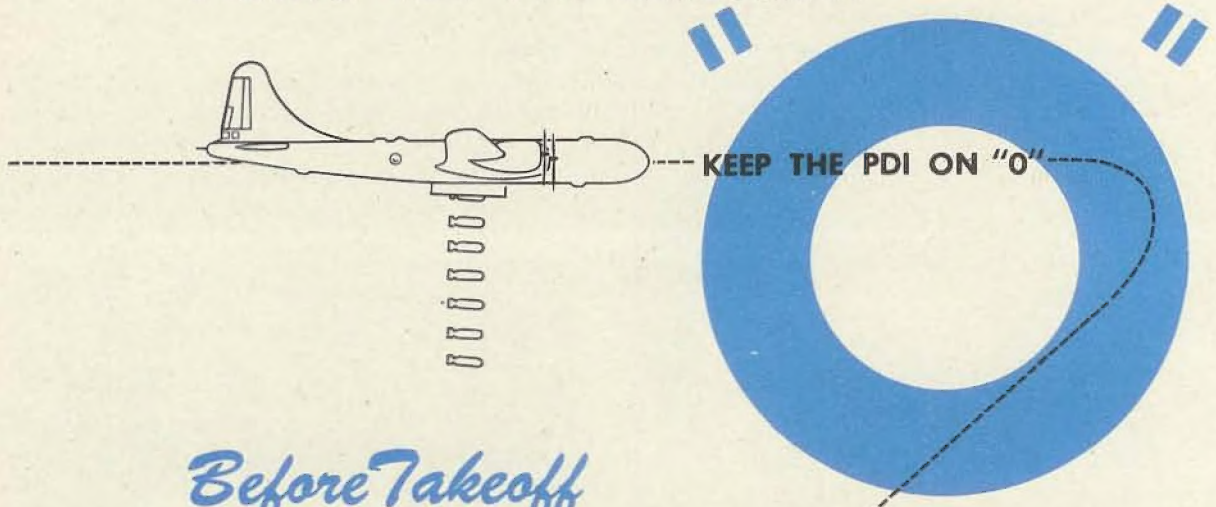
The **dashpot** on the stabilizer regulates the amount of rudder kick applied by the autopilot to correct rapid deviations in the turn axis. If



a rudder hunt develops which cannot be eliminated by adjustment of rudder ratio or sensitivity, the dashpot may require adjustment. To do this, loosen the locknut on the dashpot, turning the knurled ring up or down until hunting ceases, then tighten the locknut.

Cold-Weather Operation — When temperatures are between –12° and 0°C (10° and 32°F) autopilot units must be run for 30 minutes before engaging. If you desire accurate flight control immediately after takeoff, perform the autopilot warm-up before takeoff by turning on the master switch during the engine run-up, but make sure **autopilot is off during takeoff.** If warm-up is performed during flight, allow 30 minutes after turning on master switch before engaging. When temperatures are below –12°C (10°F) units must be preheated for 1 hour before takeoff. Use special heating covers or blankets with heating tubes.

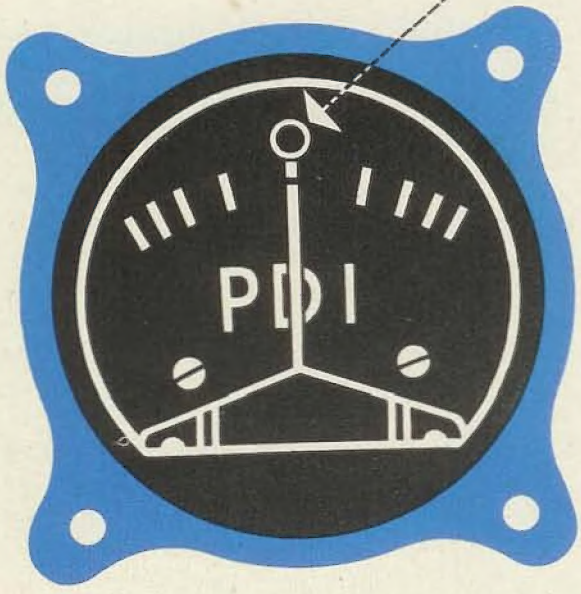
FLYING THE PDI MANUALLY



Before Takeoff

1. Check the bombardier for proper position of PDI needle for a left turn, right turn and neutral or 0 position.
2. When bombardier's PDI is left, airplane commander's PDI is right, and vice versa.

On the Bombing Run



Note: Normally bombing is done using the autopilot; however, if the autopilot is out of order the airplane commander may use the PDI.

1. To center the PDI needle, turn the plane in the direction of the needle.
2. At the beginning of the bombing run, the airplane commander can usually expect maximum PDI corrections. Avoid tendency to overcorrect by refraining from leading the needle.
3. No matter how slight the deviation of the PDI needle from 0, the needle must be immediately returned to 0.
4. Set turns must be coordinated; aileron and rudder turns, to effect more rapidly the desired degree of turn, and to avoid any excessive sliding of the bombsight lateral bubble and induced precession of the gyro.
5. Banks must never exceed 18°, to avoid tumbling of the bombsight gyro.
6. Keep PDI on 0 until bombardier calls "Bombs away."